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COVER SHEET

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Title: *Step 1: Human System Integration FY05 Pilot-Technology Interface Requirements for Command, Control and Communication (C3)*

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Abstract:

The document provides the Human System Integration(HSI) high-level functional C3 HSI requirements for the interface to the pilot. Description includes (1) the information required by the pilot to have knowledge C3 system status, and (2) the control capability needed by the pilot to obtain C3 information. Fundamentally, these requirements provide the candidate C3 technology concepts with the necessary human-related elements to make them compatible with human capabilities and limitations. The results of the analysis describe how C3 operations and functions should interface with the pilot to provide the necessary C3 functionality to the UA-pilot system. Requirements and guidelines for C3 are partitioned into three categories: (1) Pilot-Air Traffic Control (ATC) Voice Communications (2) Pilot-ATC Data Communications, and (3) command and control of the unmanned aircraft (UA). Each requirement is stated and is supported with a rationale and associated reference(s).

Status:

Document Status Work in Progress

Limitations on use:

This document is an interim deliverable. It represents the Human Systems Integration functions and performance requirements limited to enroute operations above FL430. Operations below FL430 and terminal operations have not been addressed in this document.

Step 1: Human System Integration (HSI) FY05 Pilot-Technology Interface Requirements for Command, Control, and Communications (C3)



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Technology Integrated Product Team
Human Systems Integration

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Executive Summary

Access 5 is a NASA-led project tasked to recommend the policies, procedures, and functional requirements that will ensure High Altitude Long-Endurance (HALE) Unmanned Aircraft Systems (UAS) operate as safely as other routine users of the National Airspace System (NAS). Four phases or “STEPS” are planned to systematically develop the necessary technology, policies and regulations to enable manufacturers to apply for Federal Aviation Administration (FAA) certification and approval needed to operate their civil UAS in the NAS. Current (FY05) effort limits focus to UASs that operate above 43,000 feet (STEP 1).

In order for UAS to be integrated into the NAS, it is necessary to identify the human systems integration requirements that ensure safe operations in the NAS. As a result, the Human System Integration (HSI) Work Package was established within the overall Access 5 program to address this objective. In FY05, several HSI products were developed to contribute to overall program objectives.

This product involves definition of technology interface requirements for Command, Control, and Communications (C3). This was performed through a review of C3-related, HSI requirements documents, standards, and recommended practices. Technology concepts in use by the C3 WP were assessed also.

Research of human capabilities and limitations known for C3 was performed through a review of Human-System Integration (HSI) requirements documents, standards, and recommended practices.

Technology concepts in use by the C3 WP were assessed.

Beginning with the HSI high-level functional requirement for C3, and C3 technology elements, HSI requirements for the interface to the pilot were identified. Results of the analysis describe (1) the information required by the pilot to have knowledge C3 system status, and (2) the control capability needed by the pilot to obtain C3 information. Fundamentally, these requirements provide the candidate C3 technology concepts with the necessary human-related elements to make them compatible with human capabilities and limitations. The results of the analysis describe how C3 operations and functions should interface with the pilot to provide the necessary C3 functionality to the UA-pilot system.

Requirements and guidelines for C3 are partitioned into three categories: (1) Pilot-Air Traffic Control (ATC) Voice Communications (2) Pilot-ATC Data Communications, and (3) command and control of the unmanned aircraft (UA).

Each requirement is stated and is supported with a rationale and associated reference(s).

Acronym List

ATC	Air Traffic Control
ACS	Aircraft Control Station
BLOS	Beyond Line of Sight
C2	Command and Control
C3	Command, Control, and Communications
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulation
FL	Flight Level
FRD	Functional Requirements Document
HSI	Human System Integration
LOS	Line of Sight
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
UA	Unmanned Aircraft
WP	Work Package

1. Introduction

1.1. Background

Access 5 is a NASA-led project tasked to recommend the policies, procedures, and functional requirements that will ensure High Altitude Long-Endurance (HALE) Unmanned Aircraft Systems (UAS) operate as safely as other routine users of the National Airspace System (NAS). Four phases or “STEPS” are planned to systematically develop the necessary technology, policies and regulations to enable manufacturers to apply for Federal Aviation Administration (FAA) certification and approval needed to operate their civil UAS in the NAS. Current (FY05) effort limits focus to UASs that operate above 43,000 feet (STEP 1).

In order for UAS to be integrated into the NAS, it is necessary to identify the human systems integration requirements that ensure safe operations in the NAS. As a result, the Human System Integration (HSI) Work Package was established within the overall Access 5 program to address this objective. In FY05, several HSI products were developed to contribute to overall program objectives. The FY05 HSI effort followed a standard, HSI process methodology that produced the following deliverables (Figure 1):

Deliverable 1: Human System Integration Step 1 Functional Requirement Document (FRD)

Deliverable 2: Human System Integration (HSI) Step 1 Design Guidelines for the Unmanned Aircraft System (UAS) Ground Control Station

Deliverable 3: High Altitude Long Endurance (HALE) Unmanned Aircraft System (UAS) Pilot Rating Criteria (Draft)

Deliverable 4: HSI Requirements and Guidelines for Experimental Certification of the Unmanned Aircraft System

Deliverable 5: Human Systems Integration Step 1 Pilot-Technology Interface Requirements

Deliverable 5a: Human Systems Integration Step 1 Pilot-Technology Interface Requirements for Command, Control, and Communications (C3) in Unmanned Aircraft Systems

Deliverable 5b: Human Systems Integration Step 1 Pilot-Technology Interface Requirements for Collision Avoidance in Unmanned Aircraft Systems

The following document was prepared by a collaborative team through the noted work package. This was a funded effort under the Access 5 Project.

Deliverable 5c: Human Systems Integration Step 1 Pilot-Technology Interface Requirements for Contingency Management System in Unmanned Aircraft Systems

Deliverable 5d: Human Systems Integration Step 1 Pilot-Technology Interface Requirements for the Weather System in Unmanned Aircraft Systems

Deliverable 6: Human Systems Integration Support to Simulation and Flight Test for Step 1

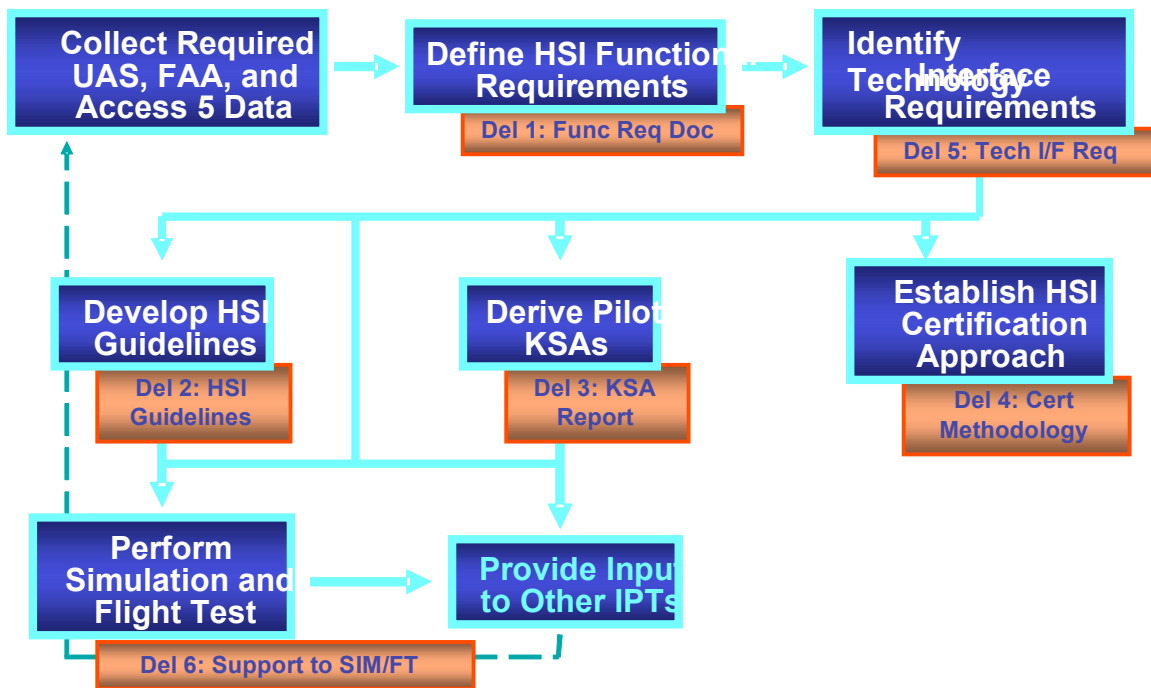


Figure 1. FY05 HSI Process and Deliverable Overview

2. Document Purpose

The purpose of this document is to define HSI technology interface requirements for C3.

Research of human capabilities and limitations known for C3 was performed through a review of Human-System Integration (HSI) requirements documents, standards, and recommended practices.

Technology concepts in use by the C3 WP were assessed.

Beginning with the HSI high-level functional requirement for C3, and C3 technology elements, HSI requirements for the interface to the pilot were identified. Results of the analysis describe (1) the information required by the pilot to have knowledge C3 system status, and (2) the control capability needed by the pilot to obtain C3 information. Fundamentally, these requirements provide the candidate C3 technology concepts with the necessary human-related elements to make them compatible with human capabilities and limitations. The results of the analysis describe how C3 operations and functions should interface with the pilot to provide the necessary C3 functionality to the UA-pilot system.

Requirements and guidelines for C3 are partitioned into three categories: (1) Pilot-Air Traffic Control (ATC) Voice Communications (2) Pilot-ATC Data Communications, and (3) command and control of the unmanned aircraft (UA).

Each requirement is stated and is supported with a rationale and associated reference(s).

3. Scope

3.1. Ground Rules

- 3.1.1. Requirements are based on Access 5 Program Command, Control, and Communications (C3) Work Package (WP) requirements and concepts as well as HSI standards and recommended practices.
- 3.1.2. Requirements defined are for the Access 5 program, Step 1, which limits scope to C3 only for flight above FL430.
- 3.1.3. Domestic Reduced Vertical Separation Minima (RVSM) rules are not considered as part of the study.
- 3.1.4. HSI Requirement Verification for dynamic operations (e.g., communications with air traffic control (ATC)) requires verification in a dynamic environment, i.e., simulation or flight test. HSI Requirement Verification for static operations (e.g., description of a control function) does not require verification in a dynamic environment, e.g., to be verified by analysis.
- 3.1.5. Requirements defined are independent of any design solution except those specified by the C3 WP.
- 3.1.6. No distinction is made between C3 requirements for line-of-sight (LOS) and beyond-line-of-sight (BLOS) HSI requirements
- 3.1.7. Requirements do not address: Aircraft equipped with ATC datalink capability.
- 3.1.8. In accordance with FARs and standard operating practices, there is no requirement for air-to-air voice (i.e., aircraft-to-aircraft) communications.

3.2. Assumptions

3.2.1. System operation is normal, all modes are fully-operational, no inhibits are active, and there are no partial failures.

3.2.2. The pilot will have all necessary control and display capabilities in the Aircraft Control Station (ACS) to satisfy HSI requirements.

4. Method

Research and documentation of human capabilities and limitations known for C3 was performed through a review of HSI requirements documents, standards, and recommended practices. Sources examined include Society of Automotive Engineers Aerospace Recommended Practices and Aerospace Resource Documents; FAA regulatory and advisory material; FAA Human Factors Design Guide; other key research papers.

The technology concepts in use by the C3 WP were assessed. These include voice communication between the UA pilot at the ACS and the air traffic controller for line of sight (LOS) and beyond line of sight (BLOS) (using communications satellite(s) and UA as a relay node), and data transmission using digital uplink and downlink for communication between the pilot at the ACS and the UA.

For these C3 technology elements, HSI requirements for the interface to the pilot (in the form of pilot information and control requirements) were identified. Fundamentally, these requirements provide the candidate technology concepts with the necessary human-related elements to make them compatible with human capabilities and limitations.

5. Technology Interface Requirements

The HSI FRD describes the highest level functional requirement for communication as follows: "The Human System Interface shall enable the pilot to communicate with ATC."¹ Technology interface requirements in this document fall under this requirement.

¹ Step 1: Human System Integration (HSI) Functional Requirements Document (FRD), Version 1.1, July 2005.

Technology interface requirements are a necessary element of the HSI functional decomposition analysis of C3 Functional and Performance requirements. The results of the analysis describe how C3 operations and functions should interface with the pilot to provide the necessary C3 functionality to the UA-pilot system.

They represent high-level, requirements for (1) pilot control of a C3 system and (2) information required by the pilot to understand vehicle operation.

Requirements and guidelines are partitioned into three categories: (1) Pilot-ATC voice communications, (2) Pilot-ATC data communications and (3) Pilot-UA command and control.

Each requirement is stated and is supported with a rationale and associated reference(s).

5.1. Pilot-ATC Voice Communications

5.1.1. Pilot-ATC Latency (Control Requirement). The time delay between pilot transmission from the ACS to reception by the air traffic controller and controller transmission to the pilot at the ACS shall not adversely affect ATC communications, air traffic controller functions, tasks, or workload. Neither shall it adversely affect pilot functions, tasks, and workload. The requirements for the pilot-ATC air-ground communications system shall limit voice delay to TBD ms. This delay represents the elapsed time from when the pilot or controller begins to speak until the audio signal is received by the listener.

5.1.1.1. Rationale. In the ATC environment, controllers and pilots have adopted a standard phraseology for conducting spoken dialogues to ensure a minimum possibility of error or misunderstanding. ATC communications safety measures, such as proper timing and read backs, assure that communication is taking place correctly. Non-standard delays in communications adversely affect operations and safety: First, delays may increase the total amount of time devoted to complete required communications tasks. Second, delays may increase the rate of deviations from the standard phraseology and procedures (e.g., partial or missing read backs) if words or pilot responses are omitted to shorten the

dialogues. Third, delays may result in more simultaneous transmissions or retransmissions if the expected time window for a response is exceeded. Finally, delays may result in the untimely delivery of messages as longer transactions are crowded onto a congested communications channel. In addition, other unwanted effects may appear including user frustration, greater variability in aircraft flight paths, blocked transmissions, and reduction in ATC service.²

5.1.2. Pilot Identification of the Active Radio in ACS (Display Requirement). The pilot shall have the capability to determine the radio in use by referring to displays and/or indicators in the ACS.

5.1.2.1. Rationale. Display only and all the necessary data to the pilot and ensure that radio usage data the pilot needs are available for display.³

5.1.3. Pilot Control of ACS Radio Functions (Control Requirement). The pilot shall have capability to operate the radio at the ACS. This includes capability to turn the radio on and off, select any frequency assigned by ATC for transmission and reception, adjust reception volume, and select radio modes.

5.1.3.1. Rationale. Operation of the radio, including the requisite control functions, is necessary in order to communicate with air traffic control.⁴

5.1.4. ACS Display of Radio Functions (Display Requirement). The pilot shall have capability to receive feedback regarding radio operation at the ACS. This includes capability to know radio on and off status, display of frequency selected for transmission and reception, reception volume setting, and radio modes (subject to radio design).

5.1.4.1. Rationale. Operation of the radio, including the requisite information content, is necessary in order to communicate with air traffic control. Display only and

² The Effect of Voice Communications Latency in High Density, Communications-Intensive Airspace. Federal Aviation Administration, Atlantic City, NJ. January, 2003.

³ Human Factors Design Guidelines for Multifunction Displays, DOT/FAA/AM-01/17, Office of Aerospace Medicine, 2001, para. 3.1.

⁴ Human Factors Design Guide Update, Report Number DOT/FAA/CT-96/01. Federal Aviation Administration, Washington, D.C. June, 2003. Sect. 7.4.5.

all the necessary data to the pilot to ensure that radio usage data the pilot needs are available for display.⁵

5.1.5. Pilot Knowledge of LOS or BLOS Status (Display Requirement). The ACS shall display to the pilot the LOS and BLOS status of communications.

5.1.5.1. Rationale. The pilot needs to know whether the system is operating LOS or BLOS. Display only and all the necessary data to the pilot to ensure that radio and datalink usage data the pilot needs are available for display.⁶

5.2. Pilot-ATC Data Communications

5.2.1. Pilot Control of ACS UA Transponder (Control Requirement). The pilot shall have capability to control the aircraft transponder at the ACS. This includes capability to turn the transponder on and off, select any code assigned by ATC, select codes 7600 and 7700, activate the IDENT function, and select transponder modes.

5.2.1.1. Rationale. Operation of the transponder, including the requisite control functions, is necessary in order to communicate with air traffic control and some airborne collision avoidance systems.⁷

5.2.2. ACS Display of UA Transponder Functions (Display Requirement). The ACS shall display feedback to the pilot regarding transponder operation at the ACS. This includes capability to present transponder on and off status, display of code selected, and transponder modes.

5.2.2.1. Rationale. Operation of the transponder, including the requisite information content, is necessary in order to communicate with air traffic control and some collision avoidance systems in other aircraft. Display only and all the necessary data to the pilot to ensure

⁵ Human Factors Design Guidelines for Multifunction Displays, DOT/FAA/AM-01/17, Office of Aerospace Medicine, 2001, para. 3.1.

⁶ Human Factors Design Guidelines for Multifunction Displays, DOT/FAA/AM-01/17, Office of Aerospace Medicine, 2001, para. 3.1.

⁷ Human Factors Design Guide Update, Report Number DOT/FAA/CT-96/01. Federal Aviation Administration, Washington, D.C. June, 2003. Sect. 7.4.5.

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that transponder usage data the pilot needs are available for display.⁸

5.3. Command and Control (C2)

5.3.1. Pilot Control of Flight Path or Trajectory (Control Requirement). The pilot shall have control capability at the ACS to authorize datalink actions prior to enabling control of the vehicle flight path or trajectory.

5.3.1.1. Rationale. As the pilot is the final authority for safe operation of the aircraft, the pilot must have the ability to control the state of the flight control system and any related system(s) that affect control over flight path or trajectory.

5.3.2. ACS Display of Flight Path Information (Display Requirement). The pilot shall have information available at the ACS that indicates authorized datalink actions prior to enabling control of the vehicle flight path or trajectory.

5.3.2.1. Rationale. As the pilot is the final authority for safe operation of the aircraft, the pilot must have the ability to know the state of the flight control system and any related system(s) that affect flight path or trajectory. The pilot must maintain specific situation awareness so that manual or automatic flight control is affected safely⁹.

5.3.3. Pilot-Vehicle (Flight Control System (FCS)) Coupling (Control and Display Requirement). The pilot shall have information and control capability so that pilot-UA interactions are not adverse, unfavorable, nor compromise safety. Unfavorable interactions include anomalous aircraft-pilot coupling (APC) interactions (closed loop), pilot-involved oscillations (categories I, II or III), and non-oscillatory APC events (e.g., divergence).

5.3.3.1. Rationale. For UA that require some element of manual control in LOS or BLOS operation, either as a primary or backup FCS mode, the UAS communication link shall not contribute to increased

⁸ Human Factors Design Guidelines for Multifunction Displays, DOT/FAA/AM-01/17, Office of Aerospace Medicine, 2001, para. 3.1.

⁹ Human Factors Requirements for Datalink. Air Transport Association Information Transfer Subcommittee. June, 1992, Para. 2.6.

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pilot flight control workload to the extent that pilot-vehicle coupling is produced.¹⁰

5.3.4. ACS Display of Data for System Security (Display Requirement). The ACS shall display feedback to the pilot regarding the source of downlink transmissions by reference to downlink data displayed at the ACS.

5.3.4.1. Rationale. The ACS shall display only and all necessary data to ensure that datalink security information are available to the pilot.¹¹

5.3.5. ACS Display of Data Describing Downlink Data Corruption (Display Requirement). The pilot shall not be presented with downlink data on ACS displays that have been corrupted, as determined by a datalink system function that checks the integrity of the downlink data prior to its display to the pilot.

5.3.5.1. Rationale. The level of data integrity must be high enough to ensure that the message that appears on the ACS display accurately and completely represents output from the vehicle¹².

5.3.6. ACS Display of Data Describing Downlink Error Checking (Display Requirement). To the extent that the datalink system may be unable to detect certain types of errors, the ACS shall display feedback to the pilot regarding reasonableness of data so the pilot may determine implications for operation of the vehicle.

5.3.6.1. Rationale. If a datalink system cannot check 100% of downlink data for security and correctness, a backup means of error checking is necessary. The pilot can serve this function at the ACS by inspection of data parameters related to the downlink as well as other systems. To the extent that the pilot is assigned

¹⁰ Aviation safety and Pilot Control. – Understanding and Preventing Unfavorable Pilot-Vehicle Interactions. National Research Council - Committee on the Effects of Aircraft-Pilot Coupling on Flight Safety. National Academy Press. 1997.

¹¹ Human Factors Design Guidelines for Multifunction Displays, DOT/FAA/AM-01/17, Office of Aerospace Medicine, 2001, para. 3.1.

¹² Human Factors Requirements for Datalink. Air Transport Association Information Transfer Subcommittee. June, 1992, Para. 4.2, 5.1.3.

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this responsibility, procedures are required to ensure proper pilot performance¹³.

5.3.7. ACS Display of Data Describing Error Messages in Response to Unrecognized Pilot Entry (Control and Display Requirement). Any unrecognized entry made by the pilot at the ACS shall cause an informative error message to be displayed and not affect the status or operation of any system.

5.3.7.1. Rationale. When the operator attempts to make an entry that the system cannot process, (1) an error message should be displayed to the pilot so the pilot clearly understands the nature of the error and is able to take corrective action. In addition, (2) no such erroneous entry should affect systems operation as the entry made by the pilot may be misinterpreted by the system and result in an inadvertent system operation and safety impact¹⁴.

5.3.8. ACS Display of Data Describing Downlink Data Corruption (Display Requirement). The ACS shall display feedback of downlink data corruption.

5.3.8.1. Rationale. As the pilot will be involved in many ACS operations, it is not expected that the pilot will monitor datalink system status at all times. Humans are poor monitors over extended period of time. As a result, augmentation of pilot monitoring skill is required in the form of a visual alert and/or aural alert to inform the pilot of a change in system operational status.^{15 16}

5.3.9. ACS Display of Data Describing Datalink Feedback in Response to a Pilot Data Entry (Display Requirement). The ACS shall display timely feedback to the pilot regarding the

¹³ Human Factors Requirements for Datalink. Air Transport Association Information Transfer Subcommittee. June, 1992, Para. 3.1.

Human Factors Design Guide Update, Report Number DOT/FAA/CT-96/01. Federal Aviation Administration, Washington, D.C. June, 2003.

¹⁴ Human Factors Requirements for Datalink. Air Transport Association Information Transfer Subcommittee. June, 1992, Para. 5.2.3.

¹⁵ Human Interface Criteria for Cockpit Display of Traffic Information, Aerospace Recommended Practice (ARP) 5365. 1999, para. 4.5, 9.1.1.7.

Human Factors Design Guide Update, Report Number DOT/FAA/CT-96/01. Federal Aviation Administration. 2002, para. 5.8.2, 5.1.16, 5.3.3, 5.3.4, 5.5.7, sect. 5.6, 5.7.

¹⁶ Human Factors Design Guide Update, Report Number DOT/FAA/CT-96/01. Federal Aviation Administration, Washington, D.C. June, 2003. Sect. 7.1.1.

content of a command and when a command has been entered into the system.

5.3.9.1. Rationale. Feedback provided to the pilot should appear in a timely manner, such that (1) the pilot has no doubt that the entered command (which generates feedback) is as intended, (2) a command is recognized by the system, (3) the pilot can determine whether further action is required, and (4) is not unsure of system status leading to an erroneous double command entry¹⁷.

5.3.10. ACS Display of Data Describing Arrival of a Datalink Message (Display Requirement). The ACS shall display feedback to the pilot when a datalink message arrives by a visual and/or aural alert.

5.3.10.1. Rationale. As the pilot will be involved in many ACS operations, it is not expected that the pilot will monitor the datalink system at all times. Humans are poor monitors over extended period of time. As a result, augmentation of pilot monitoring skill is required in the form of a visual alert and/or aural alert to inform the pilot of a change in system operational status.^{18 19}
²⁰

5.3.11. ACS Display of Data Describing Datalink Quality (Display Requirement). The ACS shall display feedback to the pilot regarding the status or quality of each uplink and downlink.

5.3.11.1. Rationale. Display only and all the necessary data to the pilot and ensure that datalink quality data will be available for display.²¹

¹⁷ Human Factors Requirements for Datalink. Air Transport Association Information Transfer Subcommittee. June, 1992, Para. 5.2.1.

¹⁸ Human Interface Criteria for Cockpit Display of Traffic Information, Aerospace Recommended Practice (ARP) 5365. 1999, para. 4.5, 9.1.1.7.

Human Factors Design Guide Update, Report Number DOT/FAA/CT-96/01. Federal Aviation Administration. 2002, para. 5.8.2, 5.1.16, 5.3.3, 5.3.4, 5.5.7, sect. 5.6, 5.7.

¹⁹ Human Factors Design Guide Update, Report Number DOT/FAA/CT-96/01. Federal Aviation Administration, Washington, D.C. June, 2003. Sect. 7.1.1.

²⁰ Human Factors Design Guide Update, Report Number DOT/FAA/CT-96/01. Federal Aviation Administration, Washington, D.C. June, 2003. Sect. 7.1.2.

²¹ Human Factors Design Guidelines for Multifunction Displays, DOT/FAA/AM-01/17, Office of Aerospace Medicine, 2001, para. 3.1.

5.3.12. ACS Display of Data Describing Datalink Status/Quality Failure (Display Requirement). The ACS shall display feedback to the pilot for any partial or full failure of a datalink.

5.3.12.1. Rationale. As the pilot will be involved in many ACS operations, it is not expected that the pilot will monitor the datalink status display at all times. Humans are poor monitors over extended period of time. As a result, augmentation of pilot monitoring skill is required in the form of a master visual alert and/or aural alert to warn the pilot of a datalink failure²². In addition, a message should be presented to the pilot on ACS displays or indicators describing which datalink has failed and the extent of the failure, as appropriate²³.

5.3.13. Reliability of ACS Display of Data Describing Datalink Status/Quality Failure Alert (Display Requirement). The datalink status/quality failure alert provided to the pilot at the ACS shall not itself be subject to a silent failure.

5.3.13.1. Rationale. To ensure that the pilot is informed if any part of the datalink system malfunctions, a datalink alerting function is required that itself does not fail with the datalink²⁴.

6. Future Work

6.1. Step 1 Lower Level Information and Control Requirements.

The requirements described in this document represent a high level definition for pilot information and control capability. Future work is required to continue this analysis to the level appropriate to the needs of the program and its customers,

²² Human Factors Design Guide Update, Report Number DOT/FAA/CT-96/01. Federal Aviation Administration. 2002, para. 7.1.1.1.

Human Interface Criteria for Collision Avoidance Systems in Transport Aircraft, Aerospace Recommended Practice (ARP) 4153. Society of Automotive Engineers. 1988, para. 4a.

²³ Human Factors Requirements for Datalink. Air Transport Association Information Transfer Subcommittee. June, 1992, Para. 5.8.3.

Human Factors Design Guide Update, Report Number DOT/FAA/CT-96/01. Federal Aviation Administration, Washington, D.C. June, 2003. Sect. 7.1.1.

²⁴ Human Factors Requirements for Datalink. Air Transport Association Information Transfer Subcommittee. June, 1992, Para. 5.8.3.

Human Factors Design Guide Update, Report Number DOT/FAA/CT-96/01. Federal Aviation Administration, Washington, D.C. June, 2003. Sect. 7.1.1.

(e.g., the FAA). Lower level information and control requirements will provide the FAA and manufacturers with an appropriate level of guidance without restricting the flexibility of design. The level of detail required is exemplified in FAR 23.777, "Means must be provided to indicate to the flight crew the tank or function selected." For Access 5 purposes, an analogous information requirement would read, "(For the top-level, Aviate functional requirement) A means must be provided at the ACS to indicate to the pilot the tank or function selected." Once this level of detail is developed for each top-level functional requirement, the information and control requirements definition effort for Step 1 will be complete.

6.2. Step 2, 3, and 4 Information and Control Requirements.

After work for Step 1 has been completed, information and control requirements analyses are necessary for the succeeding Steps. The analysis will follow the functional requirements developed for these Steps and will focus on phases from takeoff to cruise and from cruise to landing. The analysis for altitudes between approximately FL180 and FL430 will require only minor additions to Step 1 results. Significantly new information will be produced from this analysis for the critical takeoff, climb, approach, and landing phases.

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